

# Mobile ObserVations of Ultrafine Particles (MOV-UP) Advisory

January 23, 2019  
Highline Forum

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# Outline

1. Current Monitoring Status
2. Background literature updates
3. Preliminary Data Analysis
4. Discussion
5. Questions

# WA State Proviso

- Study the implications of air traffic at Sea-Tac
- Assess the concentrations of ultrafine particulate matter (UFP) in areas surrounding and directly impacted by air traffic
- Distinguish between and compare concentrations of aircraft-related and other sources of UFP
- Coordinate with local governments, and share results and solicit feedback from community
- Produce study report by December 1, 2019



## Short-term effects of airport-associated ultrafine particle exposure on lung function and inflammation in adults with asthma



Rima Habre<sup>a,\*</sup>, Hui Zhou<sup>a</sup>, Sandrah P. Eckel<sup>b</sup>, Temuulen Eneebish<sup>a</sup>, Scott Fruin<sup>a</sup>, Theresa Bastain<sup>a</sup>, Edward Rappaport<sup>a</sup>, Frank Gilliland<sup>a</sup>

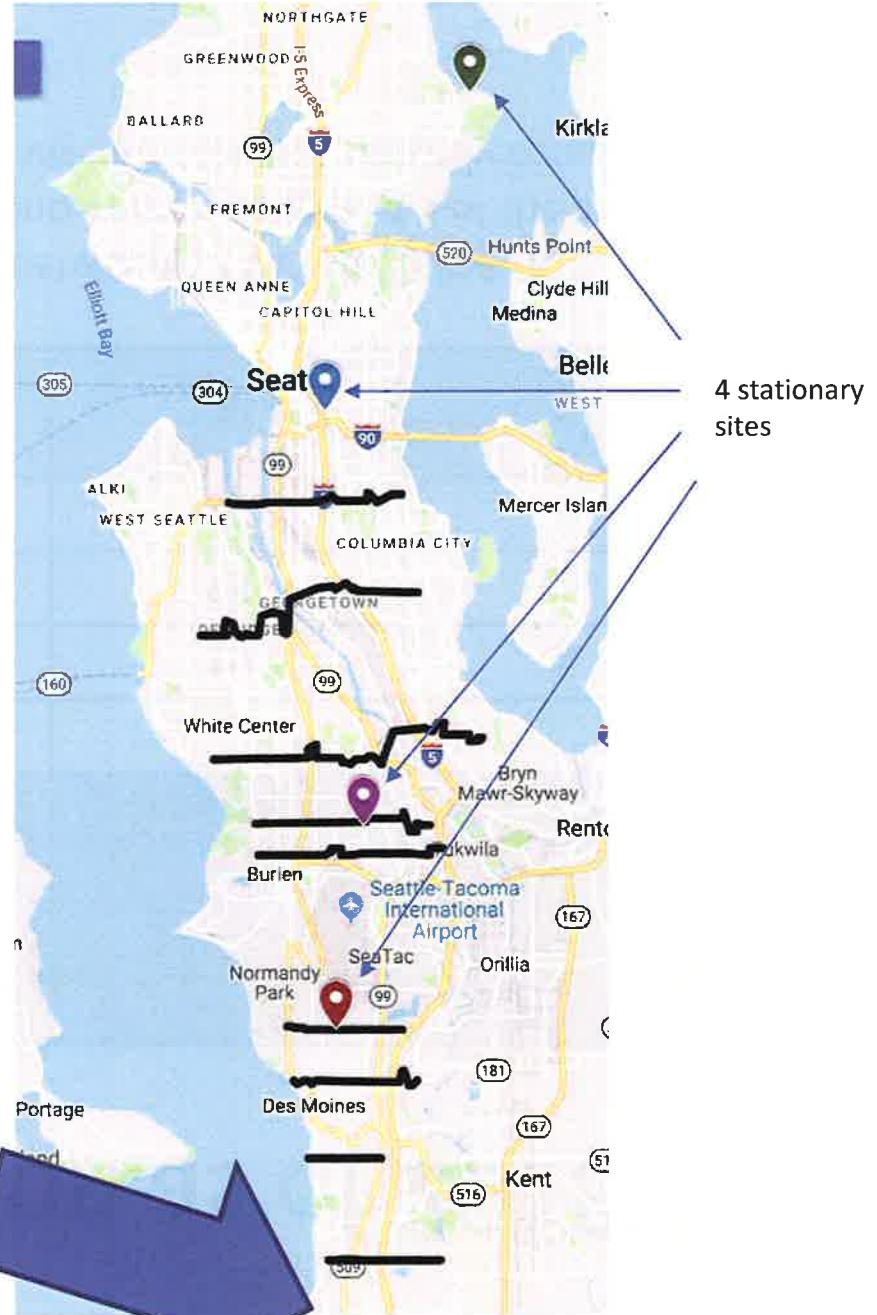
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- Randomized crossover study of 22 non-smoking adults with mild to moderate asthma
- 2-hr scripted, mild walking activity both inside and outside of the high LAX UFP impact zone (avg. difference ~30,000 /cc)
- Mean particle size at LAX impact zone was 29 nm
- “*We found significant increases in markers of systemic inflammation associated with ‘Airport UFPs’ (IL-6) and ‘Traffic’ (sTNFrlI) exposure and a significant decrease in FEV1 associated with measured PM and BC and modeled ‘Traffic’ exposure. The robust IL-6 effects we found with the ‘Airport UFPs’ source, which would have been masked by considering PN alone...”*

# MOVUP Monitoring Locations

Mobile Monitoring Transects +  
Stationary Sites



# Data collection as of 2018

Season	Number of sampling days		
	Mobile monitoring	Airport fixed sites	Near highway fixed sites
Winter 2018	16		
Spring 2018	14	10	8
Summer 2018	16	15	
Autumn 2018	12	7	
Total finished	58	32	8

- ❖ Mobile monitoring typically occurs between 12 PM and 5 PM
- ❖ Typically monitoring consists of 2 concurrent cars (N and S of the airport)
- ❖ Another round of Mobile and Fixed site monitor was recently completed in January 2019.

# Fixed Site Monitoring Status

Fixed Site Monitoring	May 4th - May 11th	June 4th - June 13th	July 13th - July 16th	July 27th - Aug 1st
10th & Weller				
Maywood				
SeaTac Community Center				
NOAA- Sand Point				

**Background Site**

# Instruments used in mobile and fixed location sampling

Parameter	Instrument
<i>Mobile and Fixed sampling:</i>	
Particle number concentration (35 nm – 1 µm)	P-Trak 8525, w/ diffusion screens
Particle number concentration (20 nm – 1 µm)	P-Trak 8525
Particle number concentration (10 nm – 1 µm)	Condensation Particle Counter 3007
Black Carbon PM	Micro-Aethalometer AE51
CO2	LI-850 Gas Analyzer
Temperature & Humidity	Hobo T, RH datalogger
Position & Time tracking	GPS Receiver DG-500
<i>Fixed Location sampling:</i>	
Particle size distribution, 13 bins	NanoScan 3910



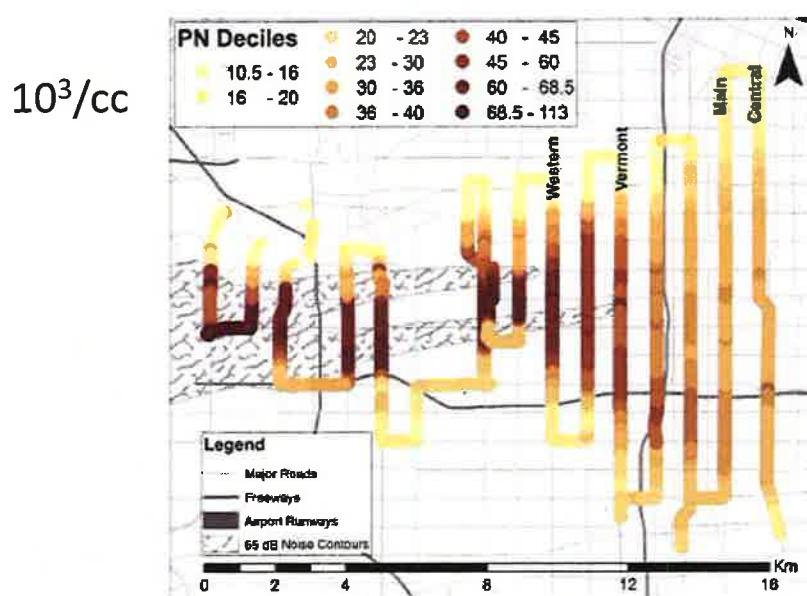
TSI, Inc. model  
3007 CPC

# MOV-UP Study

Mobile ObserVations of Ultrafine Particles (MOV-UP) Study



Area-weighted number concentration equivalent to ~ half the freeways in LA!

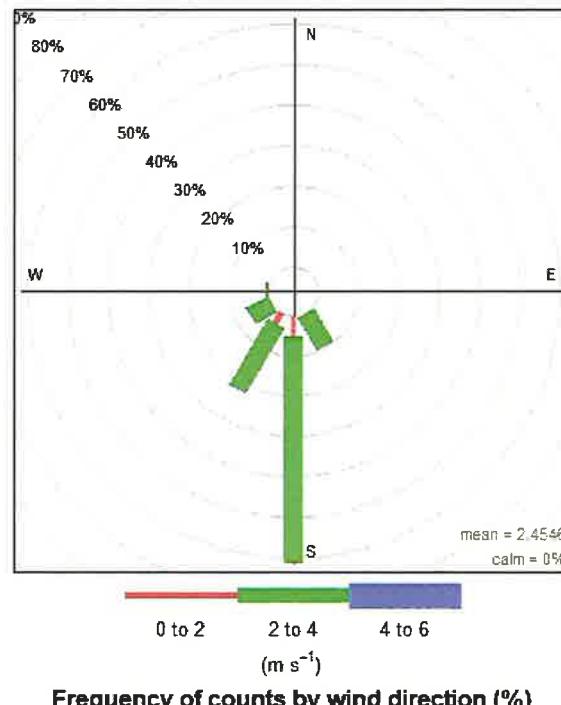


Particle size between ~10 and 30 nm diameter are present at high concentrations at ground level

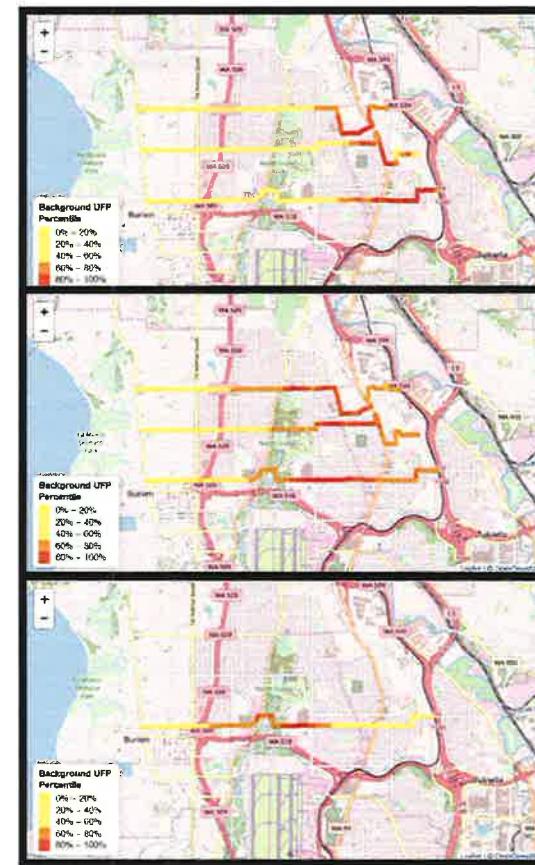
Hudda et al, ES&T 2014

# Local Background UFP (Hudda 2014 Method)

Wind Rose (Nov 21)



Plume Shifting



# **PRELIMINARY RESULTS**

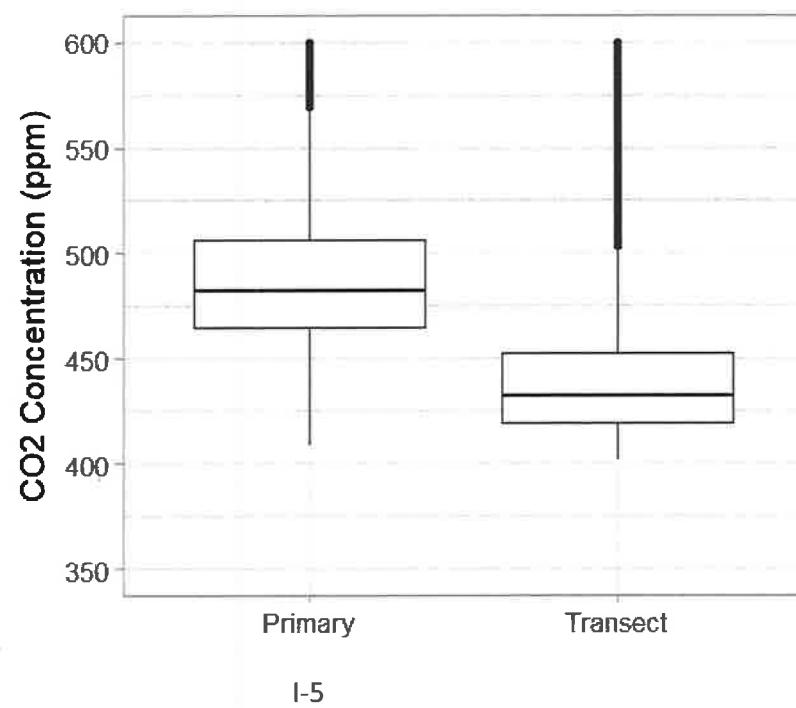
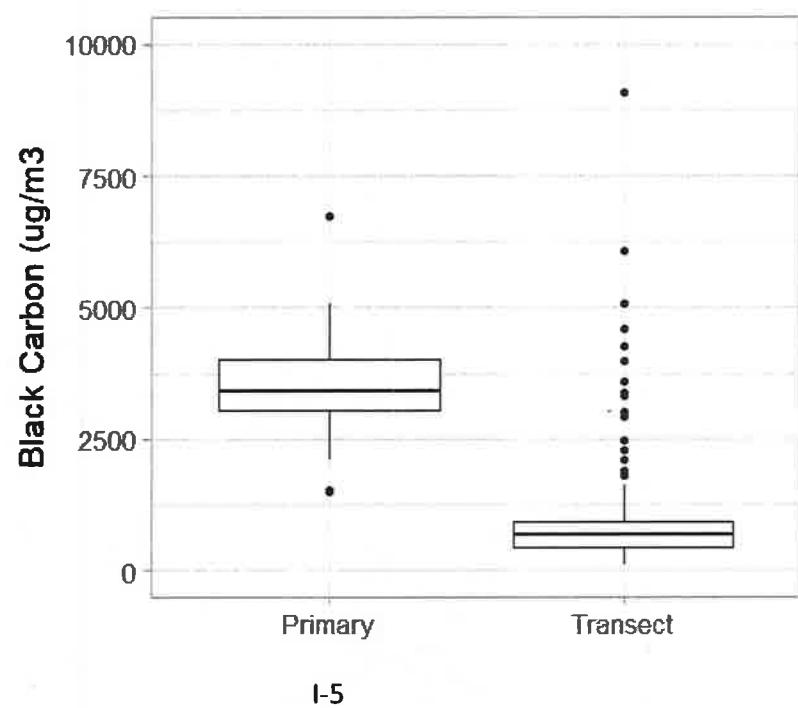
# Winter and partial Spring Mobile Monitoring (2018)

Date	Mean Temperature (F)	Predominant Wind Direction	Landing Direction (Field Notes)
7-Feb-18	53	South-east	N
8-Feb-18	52	South-west	N
9-Feb-18	48	South-west	N
12-Feb-18	44	North-west	S
13-Feb-18	46	South	N
14-Feb-18	42	South	N then S
15-Feb-18	43	South-west	N
16-Feb-18	46	South	N
7-Mar-18	48	West	S
8-Mar-18	50	South	N
9-Mar-18	49	South-west	N
12-Mar-18	71	East	S then N
13-Mar-18	51	South-west	N
14-Mar-18	50	South-west	N
15-Mar-18	54	West	S
16-Mar-18	54	South-west	S
18-Apr-18	55	South-west	S
19-Apr-18	60	West	S
20-Apr-18	59	South-west	N
23-Apr-18	66	North-west	S
24-Apr-18	74	West	S
25-Apr-18	69	North-west	S
26-Apr-18	76	North-west	S
27-Apr-18	55	South-west	N

# Measurements

## Primary Roadway (I-5) vs Transect

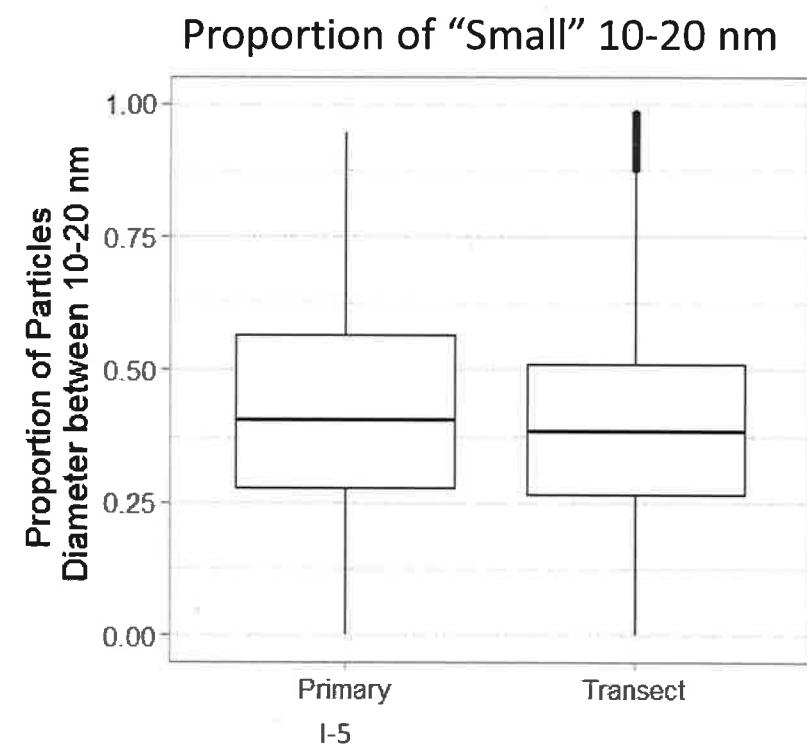
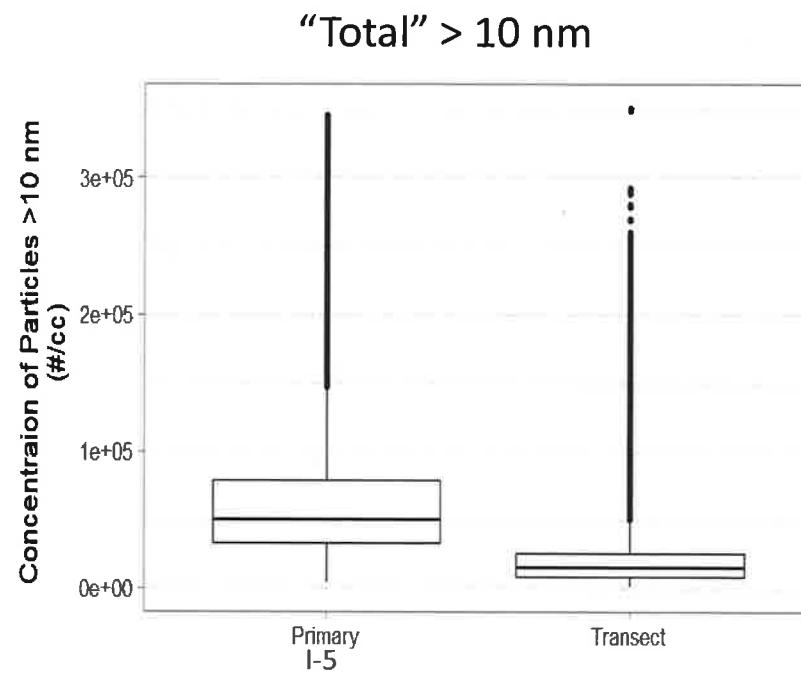
### Winter - Spring Data



# Measurements

## Primary Roadway (I-5) vs Transect

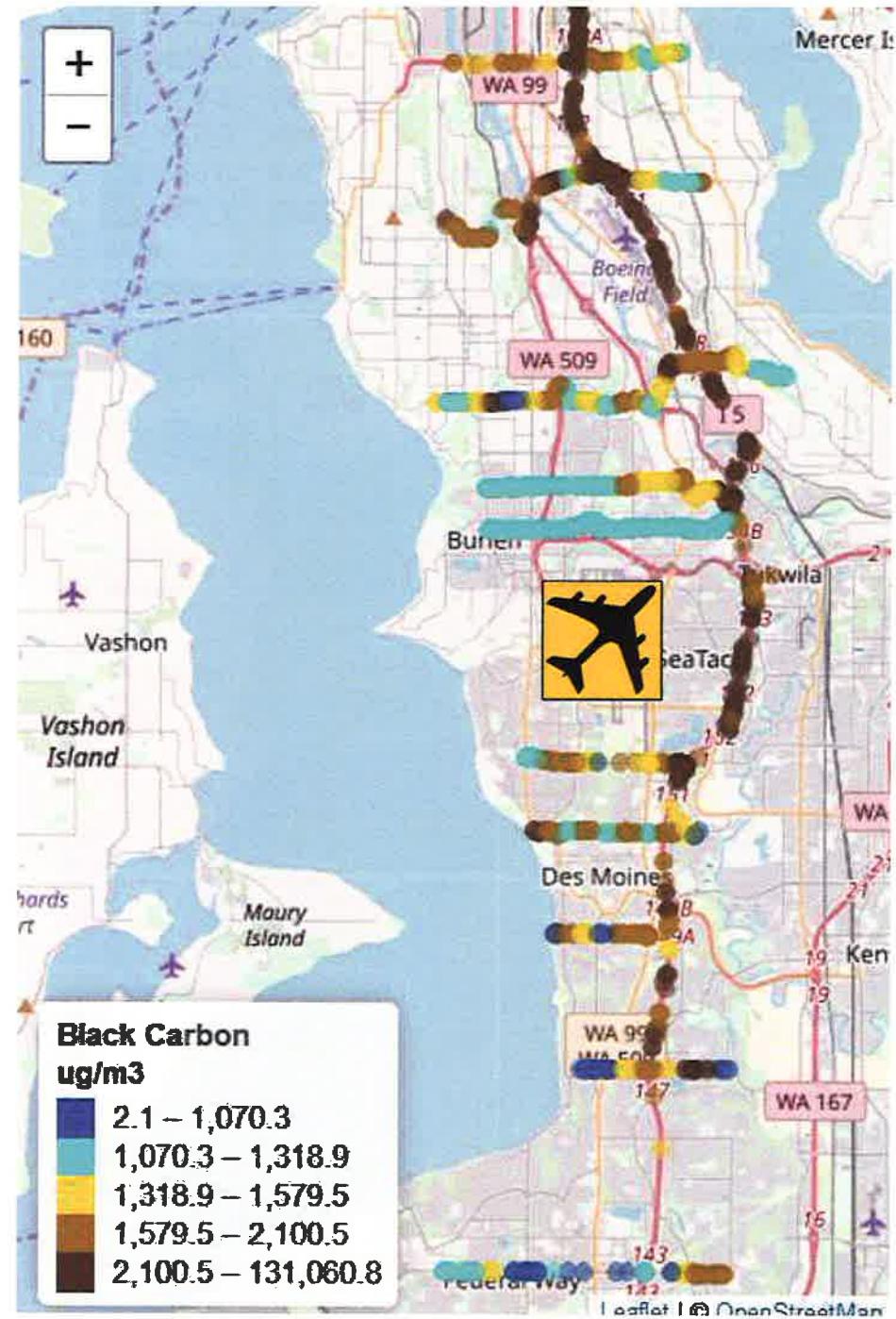
### Winter - Spring Data



# **PRELIMINARY SPATIAL DISTRIBUTION OF POLLUTANTS**

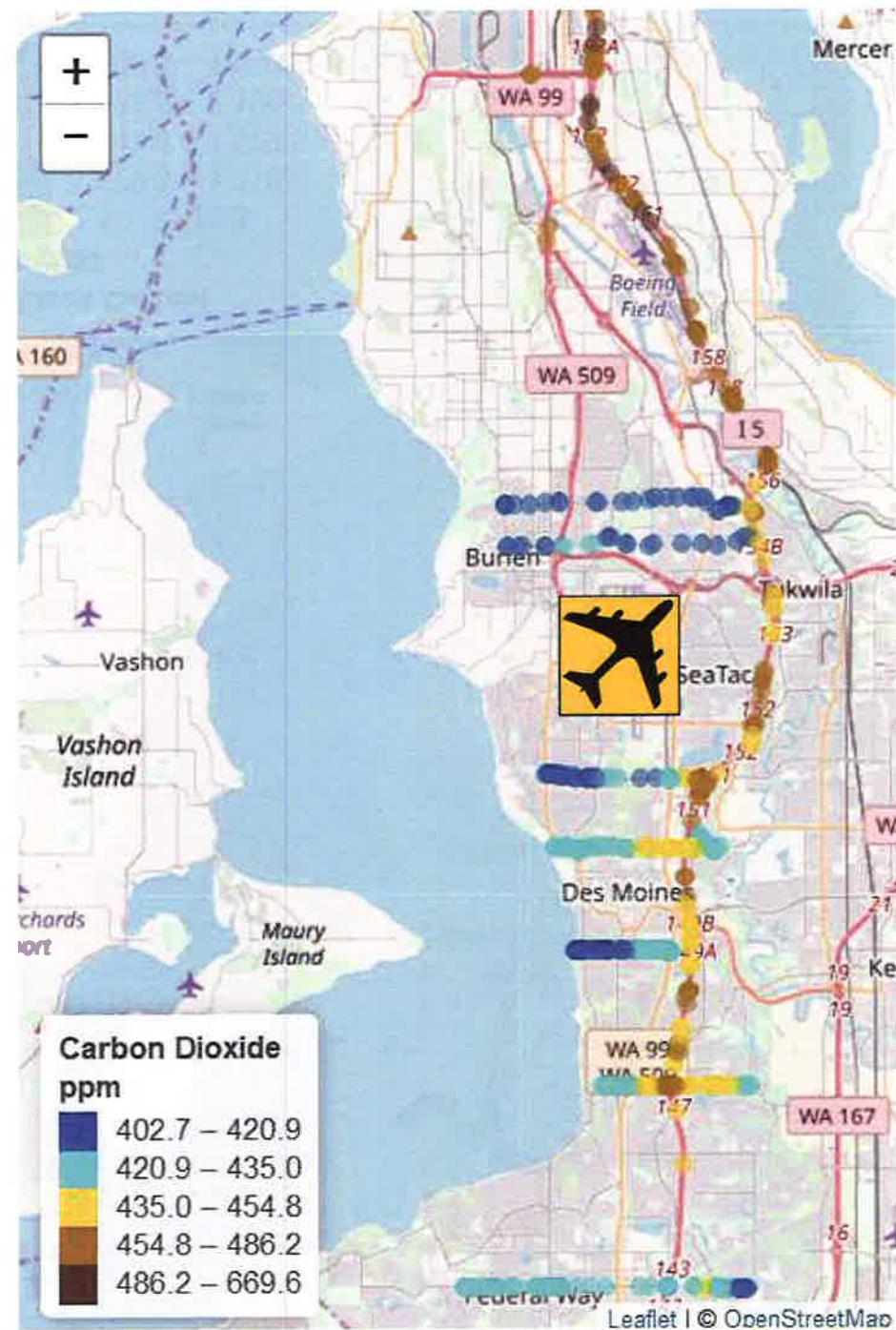
# Black Carbon Spatial Distribution

Winter - Spring Data



# Carbon Dioxide Spatial Distribution

Winter - Spring Data



# Particle Number Concentration ("Total" >10 nm) Spatial Distribution

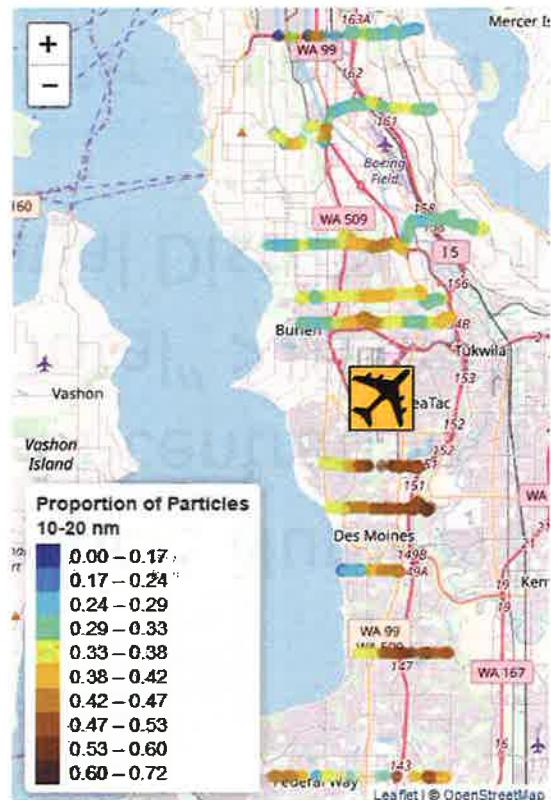
Winter - Spring Data



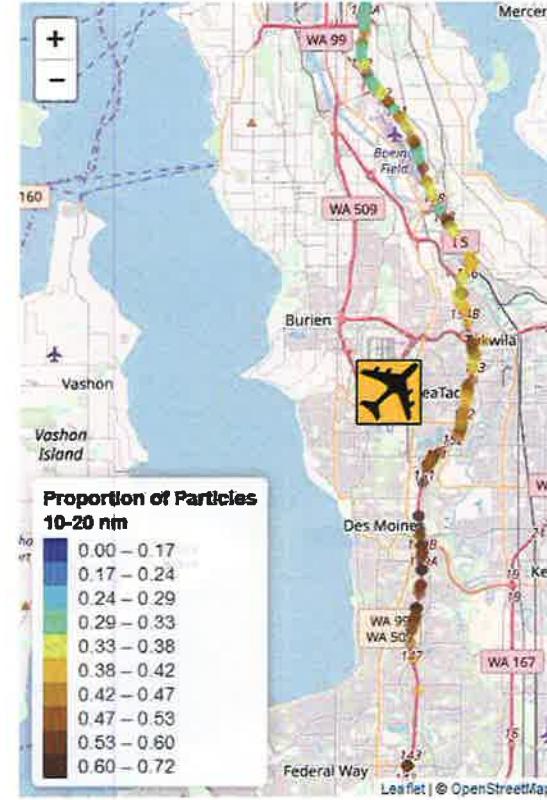
# Proportion of small 10-20 nm particles

## Transects vs Primary Road (I-5)

Proportion of Small Particles  
(10-20 nm)



Proportion of Small Particles  
(10-20 nm)

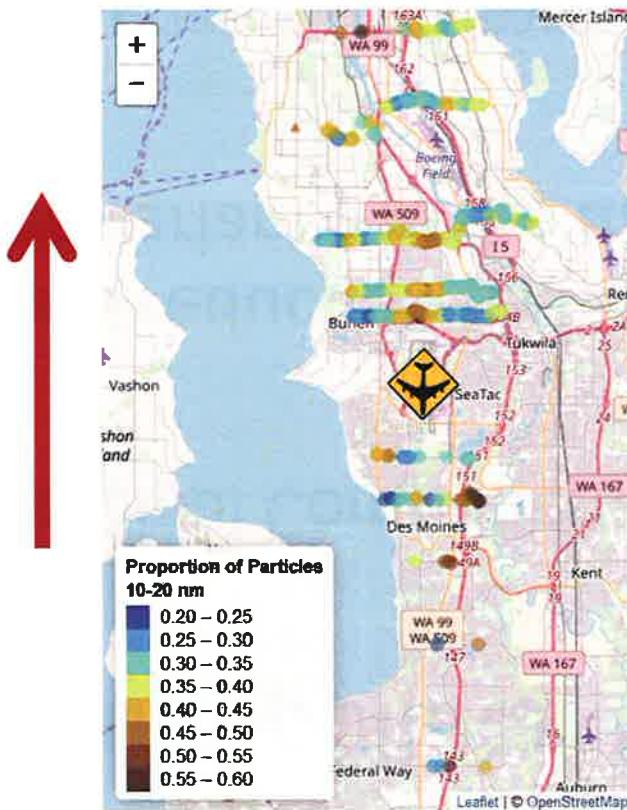


Winter – Spring Data

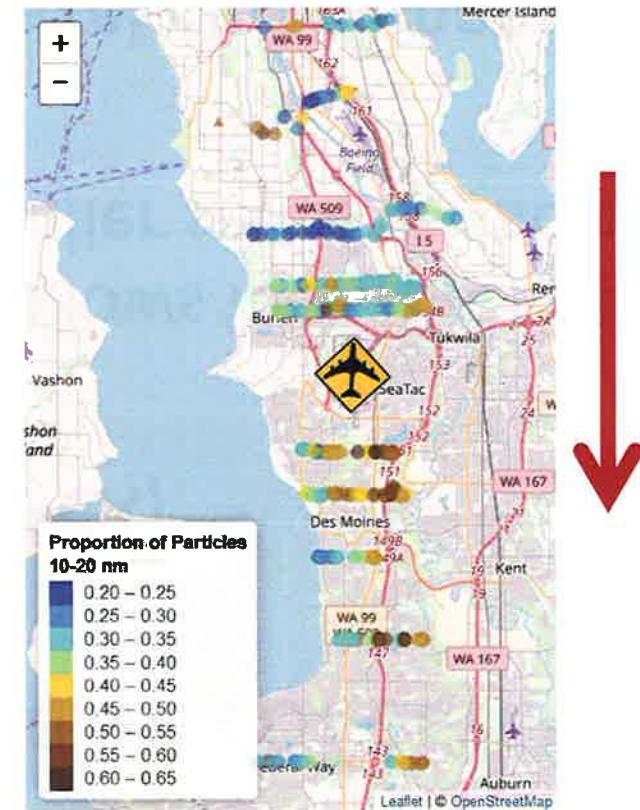
# Proportion of small 10-20 nm particles

## By Wind Direction

Wind from the SOUTH



Wind from the NORTH



Winter – Spring Data

How can we make better use of the multi-pollutant data we've collected?

## Principal Component Analysis (PCA)

Data reduction technique that allows for capturing the variance in the data in a smaller set of variables.

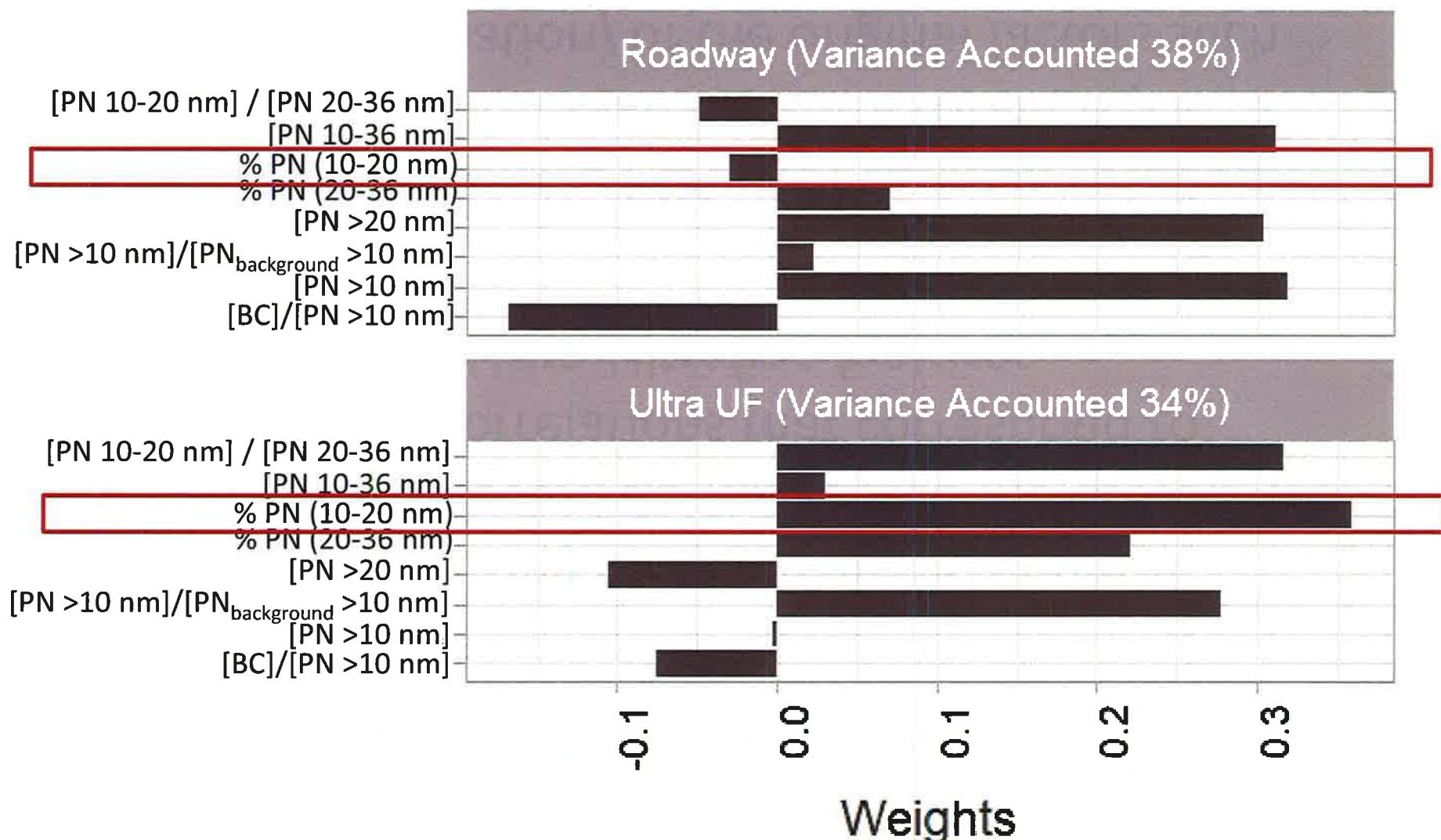
The goal is to summarize the correlations among the observed variables with a smaller set of linear combinations.

# Principal Component Analysis (PCA)

- **Hypothesis:** Using particle size distribution measures collected during mobile monitoring we can identify correlations that correspond to roadway and Ultra-Ultrafine features.
- **Method:** Perform a PCA with varimax-rotation. Varimax rotation searches for a rotation (i.e., a linear combination) of the original factors such that the variance of the loadings is maximized.

# Preliminary PCA Results

## Winter – Spring Data



# PCA Results

## “Roadway” Feature

On Transect



On I-5



Winter – Spring Data

# PCA

## “Roadway” Feature

Wind from the SOUTH



Wind from the NORTH



Winter – Spring Data

# PCA Results

## “Ultra-UF” Feature

Transects



I-5



Winter – Spring Data

# PCA

## “Ultra-UF” Feature

Wind from the SOUTH



Wind from the NORTH

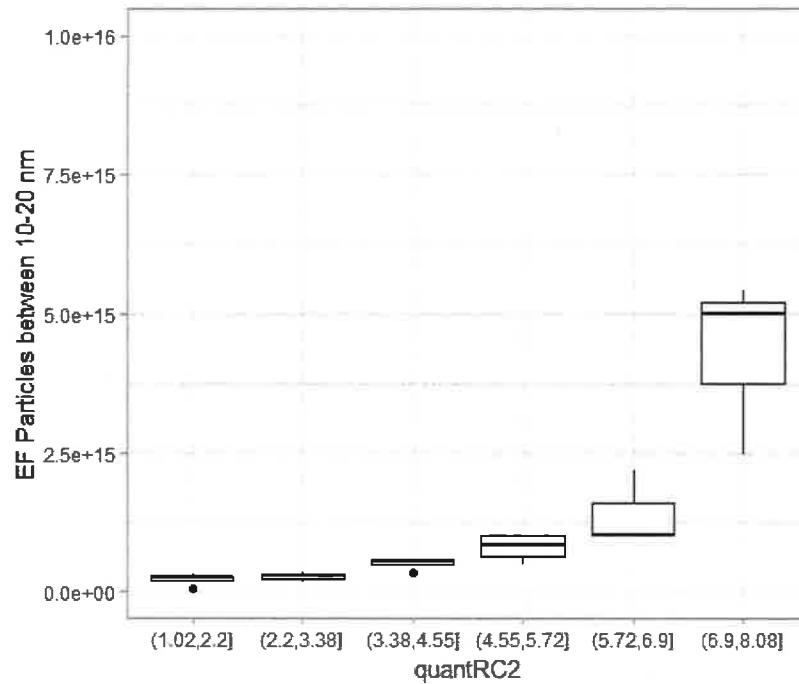


Winter – Spring Data

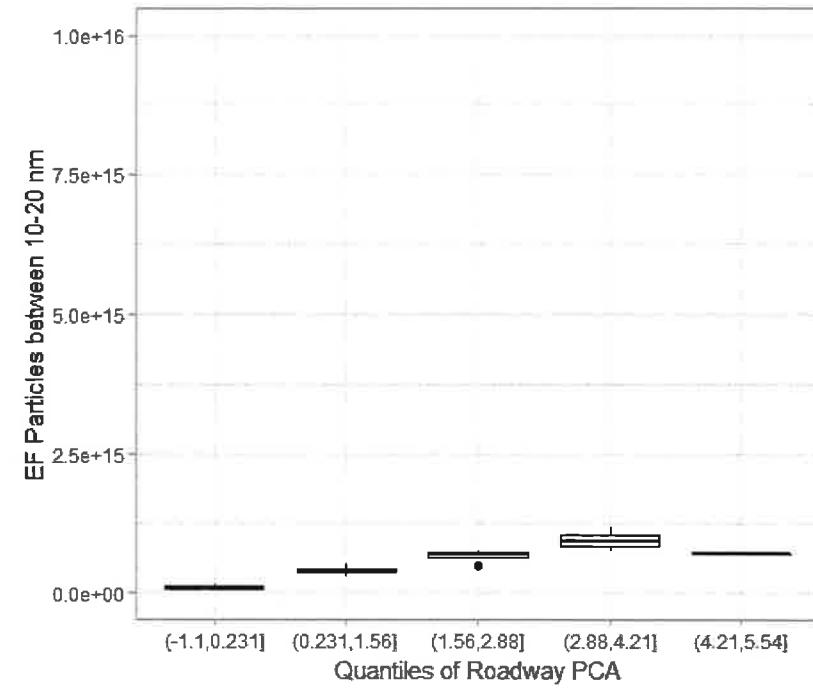
# Fuel-Based Emission Factors (EF)

## # Particles/kgC<sub>Fuel</sub>

Quantiles of PCA (Ultra-UF)



Quantiles of PCA (Roadway)



Winter – Spring Data

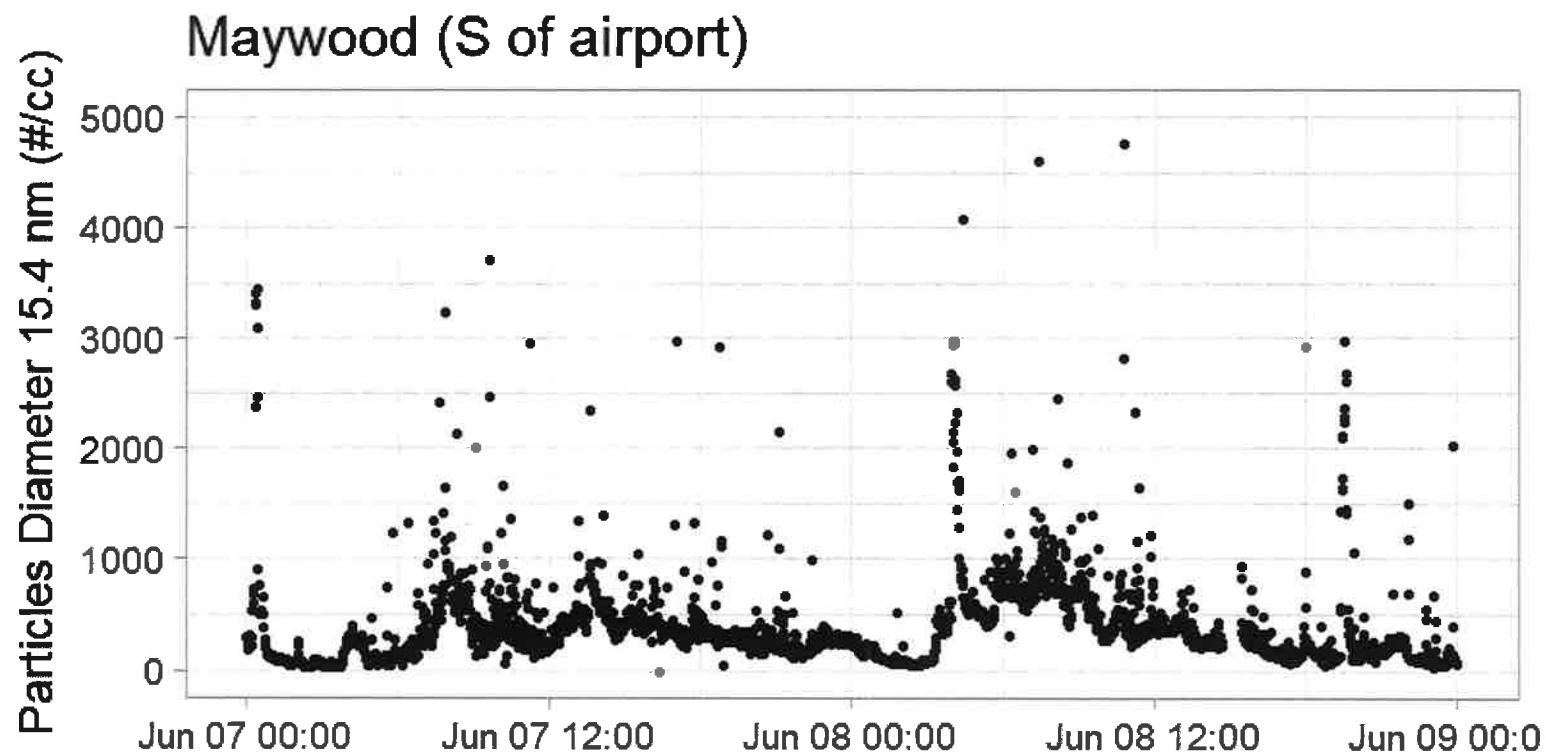
# Fuel-Based Emission of UF particles (Particles/kgC<sub>Fuel</sub>)

**Table 2**  
Summary of the results reported by previous studies for pollutants' concentrations and emission factors (EF) at different airports.

Study	Airport	Take-off/ Landing	Particle size range (nm)	Particle number (particles/cm <sup>3</sup> )	BC (µg/m <sup>3</sup> )	PM <sub>2.5</sub> (µg/m <sup>3</sup> )	EF Number (particles/kg fuel)	EF BC (g/kg fuel)	EF PM <sub>2.5</sub> (g/kg fuel)
Herndon et al., 2005	John F. Kennedy International Airport, New York, USA	Takeoff	7–2500	—	—	—	(1.0±0.7) × 10 <sup>14</sup>	—	—
Herndon et al., 2005	Logan International Airport, Boston, USA	Takeoff	7–2500	—	—	—	(8.8±7.6) × 10 <sup>15</sup>	—	—
Westerdahl et al., 2008	Los Angeles International Airport, USA	Takeoff/ Landing	7–350	2 × 10 <sup>4</sup> – 5.8 × 10 <sup>5</sup>	1.8–3.8	—	—	—	—
Fanning et al., 2007	Los Angeles International Airport, USA	Takeoff	10–100	1.4 × 10 <sup>5</sup> – 1.4 × 10 <sup>6</sup>	13.9 ± 14.3 & 14.0 ± 10.2	32–42	—	—	—
Herndon et al., 2008	Hartsfield Jackson Atlanta International Airport, USA	Takeoff	7–2500	—	—	—	1.8 × 10 <sup>15</sup> – 5.6 × 10 <sup>15</sup>	0.2–1.5	—
Hu et al., 2009	Santa Monica Airport, CA, USA	Takeoff	5.6–560	1 × 10 <sup>4</sup> – 3 × 10 <sup>5</sup>	0.7–2.7	—	5 × 10 <sup>16</sup>	—	—
Mazaheri et al., 2009	Brisbane Airport, Australia	Takeoff/ Landing	4–710	—	—	—	2.1 × 10 <sup>16</sup> – 5.4 × 10 <sup>16</sup>	—	0.2–0.3
Zhu et al., 2011	Los Angeles International Airport, USA	Takeoff	7–320	0.4 × 10 <sup>4</sup> – 8.4 × 10 <sup>4</sup>	0.01–3.6	37.1 ± 15.4	3.4 × 10 <sup>16</sup>	—	—
Klapmeyer and Marr 2012	Roanoke Regional Airport in western Virginia, USA	Takeoff	—	1.5 × 10 <sup>3</sup> – 1.7 × 10 <sup>5</sup>	—	—	1.4 × 10 <sup>16</sup> – 7.1 × 10 <sup>16</sup>	0.2–0.5	—
Lobo et al., 2012	Oakland International Airport, CA, USA	Takeoff	5–1000	2 × 10 <sup>5</sup> – 1.3 × 10 <sup>6</sup>	—	—	4 × 10 <sup>15</sup> – 2 × 10 <sup>17</sup>	—	0.1–0.7
Hudda et al., 2014	Los Angeles International Airport, USA	Takeoff/ Landing	10–1000	4 × 10 <sup>4</sup> – 6 × 10 <sup>4</sup>	1.4–1.6	—	—	—	—
Lobo et al., 2015	Hartsfield-Jackson Atlanta International Airport	Takeoff	5–1000	—	—	—	6 × 10 <sup>17</sup> – 2 × 10 <sup>18</sup>	—	0.1–0.6
Ren et al., 2016	Tianjin International Airport, China	Takeoff/ Landing	10–1000	4 × 10 <sup>4</sup> – 4.4 × 10 <sup>5</sup>	—	—	2 × 10 <sup>15</sup> – 3.2 × 10 <sup>16</sup>	—	—
Current study	Los Angeles International Airport, USA	Takeoff/ Landing	7–500	1.53 × 10 <sup>5</sup> ± 3.11 × 10 <sup>4</sup>	2.87 ± 0.03	33 ± 0.15	(8.69 ± 1.20) × 10 <sup>15</sup> (8.16 ± 1.00) × 10 <sup>15</sup>	0.12 ± 0.02 0.11 ± 0.01	0.38 ± 0.04 0.40 ± 0.05

Shirmohammadi, F., Sowlat, M. H., Hasheminassab, S., Saffari, A., Ban-Weiss, G., & Sioutas, C. (2017). Emission rates of particle number, mass and black carbon by the Los Angeles International Airport (LAX) and its impact on air quality in Los Angeles. *Atmospheric Environment*, 151, 82–93.

# Preliminary Fixed Site Small Particles ( $\sim 15.4$ nm)



# Submitted NIH Proposal in Nov 2018 for Further Study

Develop a “Selective Ultrafine Particle Respirator” (SUPR)

Selectively filters out the smallest ultrafine particles so that we can use it in controlled experiments to measure short-term health effects.

We should find out about the status of this proposal by summer 2019.



# Next Steps

- Repeat analyses on full data set
- Analyze fixed site data
- Estimate daily Emission Rates for roadways and airport
- Report by December 2019

# **QUESTIONS**